Oil Quenching Part Two: What is Your Quench-Oil A Telling You?

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- Overall performance (cooling rate or quench severity)
- Economics/cost (initial investment, maintenance, upkeep, life)
- Minimization of distortion (quench-system performance) Variability (controllable c
- Environmental concerns (recycling, waste disposal)

One additional factor – performance over time – should be added to the list since we are a ways to extend the life of our quenchants without sacrificing their performance. **By Danie**

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Relationship of Physical Properties of Quenching Oils to Performance

Table 1. Quench-Oil Test Standards	
Test	**ASTM Method**
Viscosity	D 445
Flash point	D 92
Fire point	D 92
Water	D 95/D 6304
Neutralization number	D 974
Ash	D 484
Conradson carbon residue	D 189
Precipitation number	D 91
Sludge	D 91
Specific Gravity	D 287
Quenching speed (GMQS)	D 3520
Quenching speed (Cooling curve)	D 6200

Quench oil should be routinely ana or monthly if heavily used) to determine its performance characteristics. The testing labor supplier's report (Fig. 1) should be carefully scrutinized as it contains information about th property characteristics of the oil. Oil analysis uses standard test methods (Table 1), but i deeper insights into the meaning of the test results, as opposed to just comparing them w results, we need to understand what each category is telling us.

Viscosity

Quenching performance is highly dependent on the viscosity of the oil. In general, viscosit oil degrades. Degradation can be in the form of oxidation, thermal breakdown or the prese contaminants. Oil viscosity changes with time, and the formation of sludge or varnish acce process. Samples should be taken and analyzed for contaminants and a historical record o variation kept and plotted against a process-control parameter such as part hardness.

Water Content

One of the concerns regarding oil quenching is the presence of water in the quench oil. It since, on quenching, water will form steam with a resulting volume expansion of approxim As the steam bubble rises out of the quench tank, its surface is coated with oil. As it exits (usually under extremely high pressure), it is ignited at the burnoff, resulting in a huge ev Water detectors or other in-process monitoring devices with sensitivity in the range of 0.2 provided on all quench tanks. They should be properly maintained and tested daily. Some believe that as little as 0.1% may cause dramatic changes in quenching and part surface c addition to a fire hazard, a water concentration of 0.05% has been reported to cause soft hardness and staining. When water-contaminated oil is heated, a crackling sound may be basis of a qualitative field test for the presence of water in quench oil. Sources of water in heat exchangers, water-cooled seals, plate coils or water-cooled bearings. The most comn tests for water contamination are either a Karl Fisher analysis (ASTM D1744) or distillation

Flash Point

The flash point is the lowest temperature where oil vapors will ignite but will not continue
exposed to a spark or flame. The flash point is the maximum safe operating temperature
changes in the flash point indicate contamination of the quench bath. There are two types
values that may be determined – closed-cup or open-cup. In the closed-cup measurement
vapor are heated in a closed system. Traces of low-boiling contaminants may concentrate
phase, resulting in a relatively low value. When conducting the open-cup flash point, the r
boiling by-products are lost during heating and have less impact on the final value. The m
cup flash-point procedure is the "Cleveland Open Cup" procedure described in ASTM D92.
oil should be operated no higher than 150°F (65°C) below the flash point or about 100°F
flash point on quenching a full load.

Fig. 1. Typical Quench Oil Report*

Sample ID	02-190	01-1299	01-983	01-61
Date sampled	2/5/02	11/13/01	8/21/01	5/29/0
Water, % <0.1	0.001	0.006	0.018	0.01
Visc. @100°F (SUS) 75-100	92	91.6	91.3	90.6
Flash point, °F >335	350	350	350	350
Sludge, % <0.20	0.01	0.01	0.02	0.01
Precipitation No. <0.15	0.01	0.01	0.01	0.01
GMQS @ 80°F (sec) 7-10	8.9	8.9	8.6	8.8
Problems reported	None	None	None	None

Oxidation

This variable may also be monitored and is especially important in tanks running marquen
being run above their recommended operating range. Oxidation results from the buildup o
and is detected by infrared spectroscopy. It is measured by several methods, including: p
number, total acid number, sludge content and viscosity. The cooling curve will change, i
for cold oil and decreasing in speed for hot/marquenching oils. Nitrogen blanketing of the
reduce both oil oxidation and sludge formation.

Precipitation Number

The precipitation number is an indication of the tendency to form sludge. Sludge is one of
problems encountered in quench oils, and high precipitation numbers also indicate a prope
parts. Although other analyses may indicate that the quench oil is performing within speci
presence of sludge may still be sufficient to cause nonuniform heat transfer, increased the
and result in cracking and distortion. Sludge may also plug filters and foul heat-exchanger
of heat-exchanger efficiency may cause overheating, excessive foaming and possible fires
formation is caused by oxidation and polymerization of the quench oil and by localized ove
of the oil. The relative amount of sludge present in quench oil may be quantified and repo
"precipitation number." The precipitation number is determined using ASTM D91. The rela
sludge formation of new and used oil may be compared providing an estimate of remainin

Neutralization Number or Total Acid Number (TAN)

As oil degrades, it forms acidic by-products. The amount of these by-products may be det
chemical analysis. The most common method is the neutralization number. The neutraliza

determined by establishing the net acidity against a known standard base such as potassiu
(KOH). This is known as the "total acid number" (TAN) and is reported as milligrams of KO
sample (mg/g). The TAN is an indication of the level of oxidation. As the TAN increases, th
becomes less stable and the maximum cooling rate increases while distortion, cracking an
tendencies increase. Both precipitation number and total acid number are controlled by filt

Quench Speed

Quench speed (see Industrial Heating, August 2007, "Part One: How to Interpret Cooling C
important measure of the oil's ability to achieve its performance properties. It can be dete
methods, GM Quench-O-Meter (GMQS) and cooling curves. Probe surface condition and th
are factors that can influence results. Data should always be referenced back to new quen

Accelerator Performance

Accelerants are often added to quench oils to return their performance characteristics clos
oils and to extend oil life. In general, it is not a good idea to mix an accelerator package fr
with oil from another. Induction coupled plasma (ICP) spectroscopy is one of the most com
the analysis of quench-oil additives. When additives (such as metal salts) are used as que
accelerators, their effectiveness can be lost over time by both drag-out and degradation. T
can be quantified by performing ICP spectroscopy – a direct analysis for metal ions – and
measures can be taken such as the addition of a specific percentage of new accelerator.

Conclusion

No matter what quenchant is used or how confident we are in its performance, routine tes
Our ability to interpret test results is equally important so that we can make informed judg
we best control our heat-treating processes.

Oil Quenching Part One: How to Interpret Cooling Curves

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